

Role of Fractal Geometry in Indian Hindu Temple Architecture

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Abstract— The self-similar recursive geometry is known as Fractal. Hindu Philosophy describes the cosmos as holonomic and self-similar in nature. In the connection of this context, fractal theory is being followed in Indian Hindu Temple Architecture much before the discovery of Fractal Theory. This paper is an attempt to find out the role of fractals in different elements of Indian Hindu temples. The study has extended from the site plan level to the minute detailing level. The discussion covers the elementary idea about the fractal theory and the basic structure of Hindu temples with supportive and self-explanatory visuals and analysis of the topic. It also focuses on the behavioural actions of fractals in Hindu temples and on the reasons behind its successful occurrence.

Keywords— Fractal geometry; Hindu cosmology; Hindu temple architecture; Iteration; Self-similar; Repetition

INTRODUCTION

Ancient Indian mathematicians were very skilful in geometry. They used the knowledge of geometry in other disciplines also. They derived many of the comprehensive conclusions with the help of geometry. The Indian old scripts are the evidences of those practices. The concept of progression can also be applied in the geometry. When this progression held in a proper manner or following a rule, it becomes a process, which has several names like iteration, repetition etc. However, at the end of the process, the outcome turns into a beautiful illusion. The Indians understood this beautiful illusion by practice. They were creative minds. They proved their efficiency not only in applied science but also in arts and crafts. They worshipped the nature and they were very eager to reveal the mystery of creation. Somehow they got the hints of creation; the principles of self-similarity, iteration, repetition. They observed that, in the mountains, in the trees, in ground covers, in water; everything follows those principles. Even living beings are not the exceptions. Then they followed those principles in their creations. They gave their tribute as a form of temple to the ultimate creator by following the principles of his creation. The discussions below is a small trial to reveal those process in which the ancient builders incorporate the basic principles of fractal geometry i.e. self-similarity, repetition and iteration in the making of Indian temples.

1. Fractal Geometry

The term 'Fractal' actually comes from the Latin word 'Fractus' which means 'broken'. Fractal means, the recursive geometrical forms, bearing self-similarity on different scales.

According to the Fractal Foundation – “A fractal is a never-ending pattern. Fractals are infinitely complex patterns that are self-similar across different scales. They are created by repeating a simple process repeatedly in an ongoing feedback loop. Driven by recursion, fractals are images of dynamic systems – the pictures of Chaos. Geometrically, they exist in between our familiar dimensions. Fractal patterns are extremely familiar, since nature is full of fractals. For instance: trees, rivers, coastlines, mountains, clouds, seashells, hurricanes, etc. Abstract fractals – such as the Mandelbrot Set – can be generated by a computer calculating a simple equation over and over.”

Benoît B. Mandelbrot (20 November 1924 – 14 October 2010) was a Polish-born, French and American mathematician, who first compiled all the research and ideas of hundreds of years about self-similarity and coined the term 'Fractal'.

Fractal geometry has different roles in different sectors. In Architecture, it acts as a mode of expression to reveal the beauty of the complexity. It gives wings to the ideas of an architect and reflects the process of energy flow of the universe through buildings and monuments. Hindu temples are one of the best examples of buildings with the fractal phenomenon, which were constructed in the past, long before the evolution of Fractal Theory.

2. Fractal Theory & Hindu Cosmology

'Self-similarity' is the phenomenon of each part being geometrically similar to the whole. It is the core concept of the Fractal Theory. Interestingly, self-similarity is one of the basic principles of organization in the Hindu Temple Architecture. The Hindu Temple is designed and constructed as miniature forms of the Cosmos as envisioned in Hindu philosophy and beliefs.

Hindu Philosophy describes the cosmos as holonomic. The holonomic character implies the virtue of self-similarity, homogeneity, isotropy and symmetries of various kinds. Like a hologram, each fragment of the cosmos is considered to be whole in it and to contain information similar to the whole.

3. Fractals in the Formation of Temples

The history of the evolution of the Indian Hindu Temples is a very vast field of study. Starting from the cave temples to the palatial temple complexes, all styles have followed an

exhaustive path of evolution through experimentation. During Gupta period and onwards the temple architecture in India flourished in a much disciplined manner. The architects, artisans and artisans gradually developed the aesthetic sense of complexity. As a result, the formation of Hindu temples became more complex and embodied an inherent sense of fractal geometry.

4. VASTUPURUSHAMANDALA

The Vastupurusha (figure 01) is a key concept in Hindu temple architecture. The plan of the Hindu temple strictly follows the principles described in Puranas related to the Vastupurushamandala. It follows three basic sets of iteration and further sub-categories. Limited technical expertise exists about all the mandalas and their formulation through alteration and repetition of fractals.

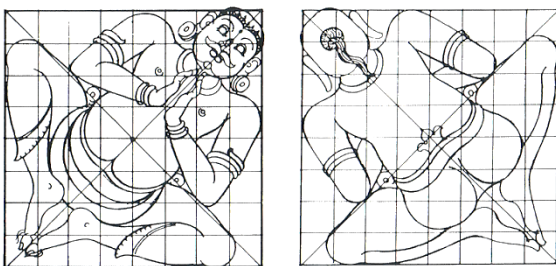


Figure 01: The image of Vastupurushamandala with 64 blocks for different deities

Source: http://hindutemplearchitectureandsculpture-filiault.wikispaces.com/file/view/Vastu_Canon.png/182843879/800x380/Vastu_Canon.png

The above figure shows the traditional Vastupurushamandala. There are mainly two types of mandalas, one is with sixty-four squares and another with eighty-one squares where each square is dedicated to a deity. (see figure 02 below)

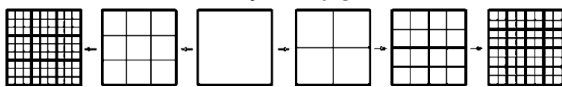


Figure 02: Fractal characteristics of different mandalas and their iterations from the sakala mandala

From left: Paramasaayika, Pitah, Sakala, Pechaka, Mahapitah, Manduka Chandita mandala

Source: I. Md Rian et al. / Building and Environment 42 (2007) 4093–4107

5. TEMPLE GEOMETRY

In Hindu temple architecture, geometry always plays a vital and enigmatic role. The geometry of a plan starts with a line, forming an angle, evolving a triangle, then a square and distinctly a circle and so on, ultimately deriving complex forms. As per the previous discussion, the occurrence of complexity, results into self-similarity and further it leads to the occurrence of fractal geometry. Geometry is a disciplined field and the fractals follow it. Both of them have definite paths of action. In following diagrams as shown in figure 03 below, the role of fractal theory in basic geometry of Hindu temple plans is exhibited.

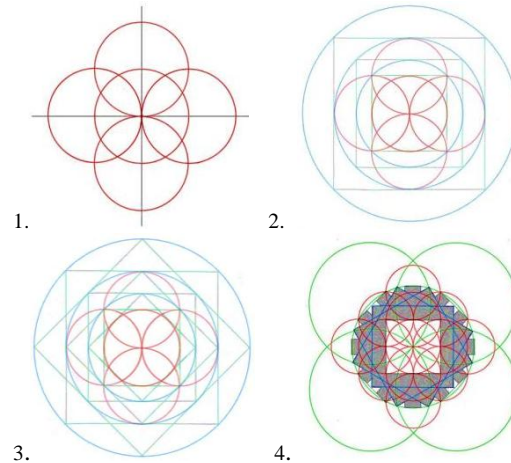
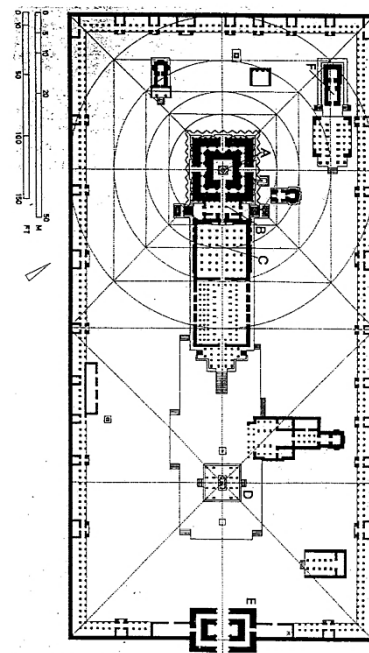


Figure 03: 1.Basic diagram, 2.Generating nested squares and circles, 3.Showing diagonal squares, 4.generation of plan forms
Source: Hardy, Adam. The Temple Architecture of India

6. VINYASASUTRA [LAYOUT & ORIENTATION]



- A Sanctuary (garbha)
- B Artha-mandapa
- C Maha-mandapa
- D Nandi-mandapa
- E Gopura
- F Shrine of Subrahmanya

Fig 1 Plan of The Brihadeshwara Temple, Thanjore. A Volwahren, Living Architecture, p 87

Figure 04: Plan of Brihadeshwara Temple, Thanjavur, showing the Vinyasasutra

Source: http://1.bp.blogspot.com/-dni34cWSH3k/UZXC_pg5RSI/AAAAAAAAAgs/qcED3dcmpT4/s1600/temple+archit.png

In Sanskrit 'Vinyasa' means orientation and 'sutra' means thread, line or axis. It is related with the lay out and orientation of temple plans. Vastupurushamandala is the base of evolution of a temple plan. Vinyasasutra comes into play after the initial evolution of the temple plan. During the determination of the axis and orientation of the temple and its surroundings, ancient architects used to follow the process described in Hindu scripts like Vastushashtra, Manasara etc. However, all the plans followed geometries with fractal character. It is postulated that, some of them were made consciously and some unconsciously. (See figure 04).

7. TEMPLE COMPLEX

The design of the temple complex varies according to the style of the temple. Most of the temples in North India do not have a boundary wall. However, in the South Indian style, it is an essential design element of the temple complex. In some areas, the entire temple complex consists of only the Mulaprasada. To the trained eye, the miniature fractals of the main shrine stand out in a well-designed temple complex. All the elements including the Toranas, Gopurams, miniature shrines, Pushkarinis etc. either have been repeated in a disciplined order or have been constructed following the rules of fractal theory.

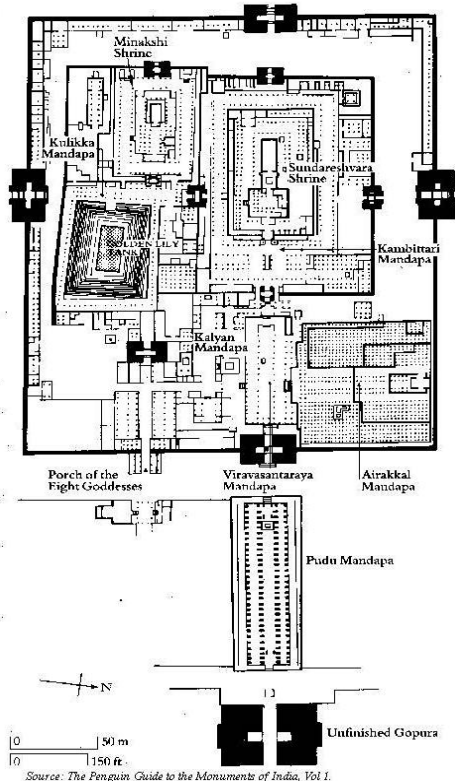


Figure 05: Site plan of Minakshi Sundareswara Temple, Madurai
Source: <http://www.art-and-archaeology.com/india/madurai/minplan.jpg>

The above example of Minakshi Sundareswara Temple (figure 05) shows how fractal has worked starting from the boundary wall to the main shrine. One can notice the positioning of the Torana, the placement of miniature replicas of the main shrine around itself, the hypostyle halls, etc. have evolved with the feature of self-similarity.

8. EVOLUTION OF PLAN FORMS THROUGH ITERATION

In keeping with the site plan, the plan of the main temple structure also follows the rule of fractals. At the very beginning, the steps are the simplest form of fractals from which the halls or mandapas grow expansively. First, the Mukhamandapa or the hall of entrance and then the Ardhmandapa, the half-heighted hall and finally the Maha Mandapa, the grand hall are positioned. After the mandapas, comes the Mulaprasada, which encloses the Garbhagriha, the inner sanctum. The enclosures of these halls and the spaces

gradually take the shape following the fractal theory (figure 06).

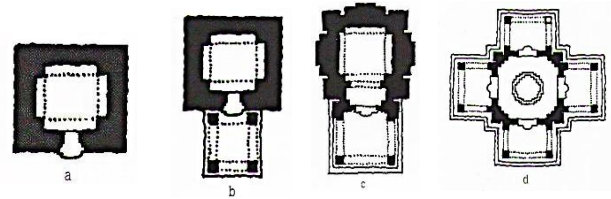


Figure 06: a. Shrine alone, b. Shrine with porch, c. Shrine with Antarala and porch, d. Sarvatobhadra shrine with four entrances
Source: Hardy, Adam. The Temple Architecture of India

The basic plan form also followed the iteration and gradually became more complex from a simple quadrangle or square plan. It follows the repetition in recesses or in projections. However, these repetitions followed a discipline. It is maintaining an axis. In the figure 07 below one can see how one formation is evolved from a simple square 'a' to 'e'. It only creates basic projections in between cardinal points. Figure 'f' to 'i' follow the repetition of recesses. Figures 'j' to 'm' are the amalgamated formations. Accordingly, the others also follow certain geometric rules for iteration.

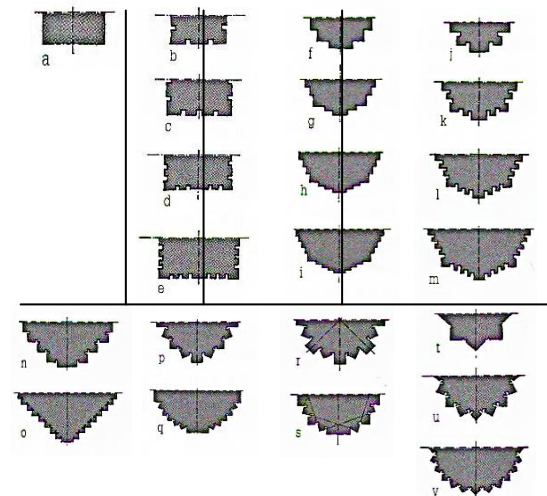


Figure 07: a. Simple square plan, (b-e). Square plan with simple projections, (f-i). Staggered square plan without recesses, (j-m). Staggered square plan with recesses, (n-o). Stepped diamond plan, (p-q). Stellate plan with orthogonal central projection, (r-s). Special stellate plans, (t-v). Uniform stellate plans based on rotated-square star.
Source: Hardy, Adam. The Temple Architecture of India

9. ELEVATION OF THE TEMPLE

Fractal also has a great impact on temple elevations. As is the case of two-dimensional plans, fractal also controls the formation of the elevations in three dimensions. Elevation treatment of temple differs according to regions in India. Therefore, tracing out typical examples, can be exhaustive. The following divisions are almost common to all temples throughout India.

Overall, the whole temple structure in three dimensions form expresses the self-similarity in the structure. On consideration of silhouettes of temple structures, a visual language of gradual progression starting from the base to the spires is prominent as shown in figure 08.



Figure 08: Silhouette of Kandariya Mahadev Temple

Source: <http://ak5.picdn.net/shutterstock/videos/1388590/preview/stock-footage-a-spire-on-an-indian-temple-stands-silhouetted-against-the-sun.jpg>

One can divide the temple into several parts like Pitha, Vedibandha, Jangha, Varandika, Sikhara and Ghanta. Ghanta is actually a part of Shikhara but its features are so distinct, one can consider it as a separate entity. The above-mentioned parts are similar in all Nagara temples, but they have different denominations in different places.

Pitha

Pitha is the base or the altar on which the structure grows along the central axis. Pitha is also divided into several parts founded on the – Khura, Kumbha, Antarpatrika, Kalasha and kapotali. All the fragments are basic moulds and repetitive in form. In *figure 09* below, the fractals of the central mould repeat in numbers around the plan in different scales.



Figure 09: Pitha of a typical North Indian Temple
Source: Hardy, Adam. The Temple Architecture of India

Vedibandha

Vedibandha is the next upper part of the pitha. It is mainly a connection between pitha and jangha. It has almost the same character of that of pitha. The mouldings and the typical parts are mostly similar in both the cases. The only difference in this case is that the sculpting of moulds is more decorative. One can find similar type of small repetitive ornamental mouldings at the central space of every wall section in *figure 10*.

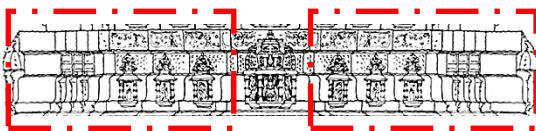


Figure 10: Vedibandha of a typical North Indian Temple Source: Hardy, Adam. The Temple Architecture of India

Jangha

Jangha is the walled section of the shrine (*figure 11*) acting, as the enclosure of the mandapas and Garbhagriha. Fractals are worked in two different ways in its formation. Initially it is generated from the folds at the very base layer, which follow the iteration. The types of decorative works on the Jangha at the outer level are also self-similar and repetitive.

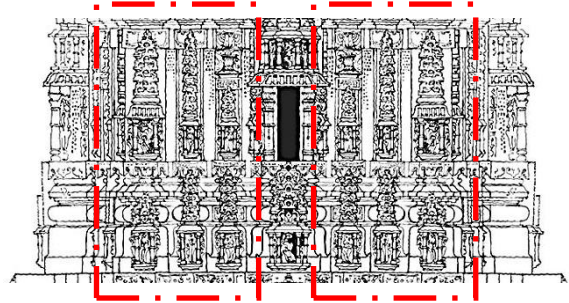


Figure 11: Jangha of a typical North Indian Temple
Source: Hardy, Adam. The Temple Architecture of India

Varandika

Varandika is the cornice part of the temple. Huge long chunk of stones are placed along the inner side to form the cornice. However, on the outside, it is quite decorative (as shown in *figure 12*) and it also forms the connection between the Jangha and the Sikhara, the two most important parts of a temple.



Figure 12: Varandika of a typical North Indian Temple
Source: Hardy, Adam. The Temple Architecture of India

Sikhara

Sikhara is the identity of a temple. All the variations in temple architecture are mainly because of the variation in its formation. (*figure 13*)

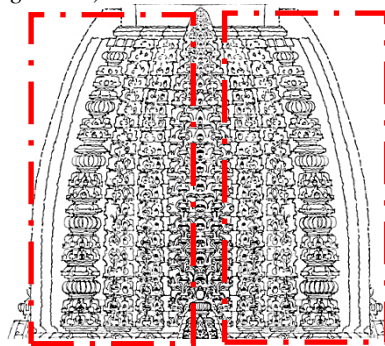


Figure 13: Sikhara of a typical North Indian Temple
Source: Hardy, Adam. The Temple Architecture of India

Ghanta

Ghanta is the topmost part of the temple. It is a part of the Sikhara. It also has separate parts with Kantha or Griva as the base and gradually Amlaka, Padmashirshaka, Kalasha, etc. The connector of Sikhara and Ghanta is known as the Kantha or the Griva. In this section of the temple, fractal mainly works in the Amlaka part by creating self-similar ribs. (as in figure 14)

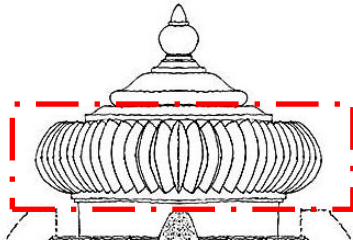


Figure 14: Ghanta of a typical North Indian Temple
Source: Hardy, Adam. The Temple Architecture of India

The formation of Jangha also depends upon the formation and style of the Sikhara as shown in the figure 15 below. It is similar to the head and the structure. One fold is added to the Jangha for every additional fold in the Sikhara.

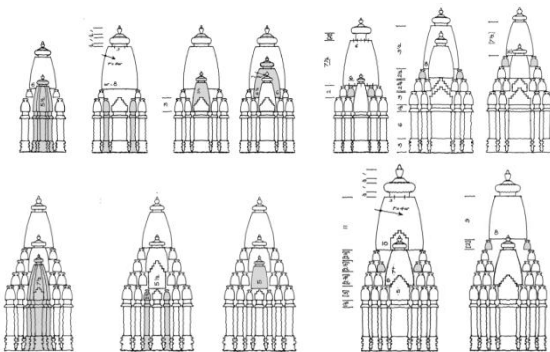


Figure 15: Image showing the interdependent formation process of Jangha and Sikhara
Source: Hardy, Adam. The Temple Architecture of India

10. THE BEHAVIOURAL ATTRIBUTES OF ACTION OF FRACTALS IN TEMPLES

From the above discussion about the role of fractal geometry in the formation of the Hindu temple, one major observation, which can be drawn, is that all the progression and iteration have some specific behavioural attributes of action. According to Professor Adam Hardy, the movements and the behaviour of action are *Projection*¹, *Staggering*², *Splitting*³, *Progressive Multiplication*⁴ and *Expanding Repetition*⁵.

11. REASON BEHIND THE USE OF FRACTAL GEOMETRY IN HINDU TEMPLE ARCHITECTURE

The following are some probable reasons behind the use of Fractal Geometry in Hindu temple architecture.

- It can be argued that, practicing fractals is none other than the implication of the sense of completeness since the concept of fractals is that of the part to whole and whole to part.
- The fractal theory fully supports the Hindu philosophical concept of 'one among all, all is one'. It brings the feeling of oneness (the concept of Atman).
- It can bring a sense of strength, both structurally as well as visually.
- Self-similar elements in the design, seek the attention of the visitors and pilgrims repeatedly and gradually entice them to think about it and create a clear state of mind with a holistic perception.
- Self-similar repetition in structure generates an identity of elements as well as form.
- Experimentation can also be a reason behind the evolution and realisation of fractal theory in Hindu temple architecture through the ages.
- The term, 'Self-similar' brings a sense of modularity. Therefore, it generates the same style of work using the same modules, which saves resources. Local materials, workmanship and time offer ease of execution across huge structures, such as temples within the same region.
- Making of similar kind of elements repeatedly generates a habit and practice and practice perfects the execution.
- From an aesthetical viewpoint, a fractal geometry brings about 'order in chaos' and thereby 'a beauty in complexity'.

12. CONCLUSION

The above study gives a brief idea about the relationship between fractal theory and Hindu cosmology, role of fractal geometry in Hindu temple architecture, behavioural attributes of action of fractals and possible reason behind them. It endeavours to prove the essential role of fractals in Hindu temple architecture.

In the view of the author, the above brief discussion about fractals, Hindu temples and their inter-relationship has renewed to their understanding of Hindu temple architecture. Study of fractals and link it to the formation of temple make the process easier of understanding the temples. It reveals the mystery of this gigantic structures fold by fold. In every element of these temples, there is a touch of fractal. This paper is just a trial of highlighting them. However, there is huge scope to study them in detail.

Notes

1. Projection of an embedded form almost by definition suggests emergence or emanation. In this process, the base module projects self-similar miniatures or fractals forward, sideways, diagonally and backwards. This projection process can change its direction after a single progression. Like, initially, it can project moulds forward and in the second turn, it projects the miniatures diagonally. (Prof. Adam Hardy)
2. Staggering, multiple projection, or progressive stepping-out, suggests expansion in stages on a serial emanation. Closely bunched offsets can also create the impression of vibration from an inner energy. A staggered sequence of forms, embedded one within the other, can be entirely at one level (in which case the elements slide out like an unfolding telescope), or step down as they step out. (Prof. Adam Hardy)
3. Two aligned halves of something familiar as a whole suggest that the whole has split; or even that the halves are still separating, especially if a projected form appears between them, as if emerging from a void. In this way, basic forms split away and create fractals. (Prof. Adam Hardy)
4. Proliferation (thus growth of the whole, but not necessarily of the parts) is portrayed where elements are arranged in a sequence of rows, starting with one and then progressively increasing in number. This process actually creates similar objects in a order like binary tree. (Prof. Adam Hardy)
5. When growth is expressed in a series, the elements are self-similar but get progressively bigger. (Prof. Adam Hardy)

Acknowledgment

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